

daytime (fig. 4), and the shutter opened for a fraction of a second, after which the time-scale device is withdrawn (fig. 5), leaving the camera clear for the night's record.

The time to open the shutter after sunset and the time to close it before sunrise in order to obtain the maximum length of record without fogging the film has been worked out as follows: An examination of exposures made by Mr. A. J. Weed during preliminary trials of the instrument discloses that the films are fogged on full moonlight nights, but not to a sufficient extent to impair the record. It may therefore be considered safe to open the shutter just at the time twilight is equal to full moonlight. Measurements made by Thiessen¹ show that this occurs when the sun is approximately $10\frac{1}{2}$ degrees below the horizon. Using the formula given in the same article, the time (90th meridian time) at Chicago when twilight is equal to full moonlight has been computed as follows:

Time when the sun's altitude is $-10^{\circ} 30'$ at Chicago.

		Apparent time.		Equation of time. (minutes.)	Including -10 minutes to reduce Chicago to 90th meridian time.	Standard time 90th meridian.	
		(p. m.).	(a. m.).			Open shutter (p. m.).	Close shutter (a. m.).
Jan.	1899.						
	1.	5:34	6:26	+4	-6	5:28	6:20
	10.	5:38	6:22	+8	-2	5:36	6:20
	20.	5:45	6:15	+11	+1	5:48	6:16
Feb.	1.	5:56	6:04	+14	+4	6:00	6:08
	10.	6:07	5:53	+14	+4	6:11	5:57
	20.	6:18	5:42	+14	+4	6:22	5:46
Mar.	1.	6:30	5:30	+12	+2	6:32	5:32
	10.	6:42	5:18	+10	0	6:42	5:18
	20.	6:57	5:03	+7	-3	6:54	5:00
Apr.	1.	7:14	4:46	+4	-6	7:08	4:40
	10.	7:28	4:32	+1	-9	7:19	4:23
	20.	7:43	4:17	-1	-11	7:32	4:06
May	1.	7:58	4:02	-3	-13	7:45	3:49
	10.	8:11	3:49	-4	-14	7:57	3:35
	20.	8:24	3:36	-4	-14	8:10	3:22
June	1.	8:35	3:25	-2	-12	8:23	3:13
	10.	8:41	3:19	-1	-11	8:30	3:08
	20.	8:43	3:17	+1	-9	8:34	3:08
July	1.	8:41	3:19	+4	-6	8:35	3:13
	10.	8:36	3:24	+5	-5	8:31	3:19
	20.	8:27	3:33	+6	-4	8:23	3:29
Aug.	1.	8:18	3:42	+6	-4	8:14	3:38
	10.	8:00	4:00	+5	-5	7:55	3:55
	20.	7:45	4:15	+3	-7	7:38	4:08
Sept.	1.	7:28	4:32	0	-10	7:18	4:22
	10.	7:15	4:45	-3	-13	7:02	4:32
	20.	7:00	5:00	-6	-19	6:41	4:41
Oct.	1.	6:45	5:15	-10	-20	6:25	4:55
	10.	6:32	5:28	-13	-23	6:09	5:05
	20.	6:19	5:41	-15	-25	5:54	5:16
Nov.	1.	6:05	5:55	-16	-26	5:39	5:29
	10.	5:55	6:05	-16	-26	5:29	5:39
	20.	5:46	6:14	-14	-24	5:22	5:50
Dec.	1.	5:38	6:22	-11	-21	5:17	6:01
	10.	5:34	6:26	-7	-17	5:17	6:09
	20.	5:32	6:28	-2	-12	5:20	6:16

Valuable suggestions and assistance in designing and constructing the device have been given by Messrs. S. P. Fergusson, R. N. Covert, A. J. Weed, Julius J. Martin, and others of the Instrument Division force.

Working drawings may be obtained at actual cost of blue prints by application addressed to Chief of the Weather Bureau.

THE DURATION OF MOONLIGHT.

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Prof. Alexander McAdie, director of the Blue Hill Observatory, has forwarded a specimen of a moonlight record obtained at the observatory by means of a Campbell-Stokes sunshine-recorder and a strip of photographic gaslight developing paper cut to fit the groove of the recorder suitable for the occasion. The whole of the record is colored uniformly gray by direct moonlight but along the center runs a black line, about 1 millimeter wide, which represents the effect of the moonlight which is focussed by the ball of the recorder upon the paper. This line is analogous to the burnt records caused by the sun, with the difference that the moonlight record is produced by the short actinic light rays from the moon, while the sun record is due to the long heat rays from the sun. This moonlight recorder thus finds its exact counterpart in the Jordan sunshine recorder.

Certain precautions will be necessary for the successful use of the Campbell-Stokes instrument as a moonlight recorder.

(1) The appropriate groove must be found for the day in question from the table of moon's declination in the Nautical Almanac or in Whitaker's Almanac. The summer groove is to be used when the moon's declination is greater than 9°N. , the winter groove when it is greater than 9°S. , and the equinoctial groove for intermediate declinations. As the moon passes through a complete cycle in declination once in a lunar month, whereas the sun passes through its cycle once a year, changes of the moon's declination are very rapid, and care will be required to change the groove when necessary. The range of the moon's declination is somewhat greater than that of the sun, but the ordinary sunshine recorder would probably just serve to obtain a complete set of moonlight records.

(2) The sensitive paper must be inserted not earlier than an hour after sunset and removed not later than an hour before sunrise; otherwise it will be completely fogged by daylight.

(3) The meridian position of the record may be indicated on the paper before it is removed from the groove by making a prick opposite the "noon" mark of the recorder. The time corresponding with this mark is the "Hour of moon's southing," and is given in the M. O. Calendar.

(4) The time scale of the moonlight recorder is a shade less open than that of the sun recorder, owing to the moon's motion in right ascension. If the length of the trace is measured on the scale provided for sunshine, the duration of moonlight may be found by adding 3 per cent to the measurement.

The observer who is interested in astronomy and the theory of the sunshine recorder will find in the use of his instrument as a moonlight recorder a very interesting and instructive exercise. If the recorder were used exclusively for moonlight recording the early rising entailed in summer by the necessity of removing the moonlight record before daybreak could be avoided by arranging for a suitable light-tight drop cover to be released at a pre-determined hour through the agency of an alarm clock.

¹ Kimball, Herbert H., The Duration and Intensity of Twilight. MONTHLY WEATHER REVIEW, vol. 44, November, 1916, p. 614-620.